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(54) Apparatus for measuring liquid volume and/or flow rate

(57) Apparatus for measuring the volume and/or rate of flow of a liquid, especially for urodynamic analysis, comprises a container (10) in which liquid (12) accummulates, an air-filled chamber (14) in communication with the interior of the container (10) at or adjacent to its base, for example via a diaphragm (16), and a pressure transducer (18) responsive to pressure changes in the air-filled chamber (14). The liquid is damped by baffles (20) in the container (10) and the air is damped by constrictions (22) in the chamber (14). The transducer output, which is proportional to liquid volume, can be processed to derive a measure of rate of flow.

FIG.1.

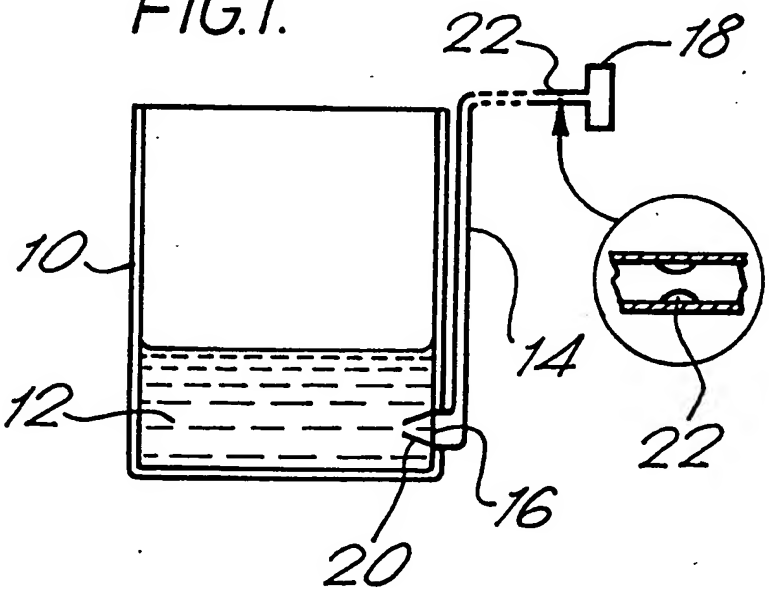

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FIG.1.

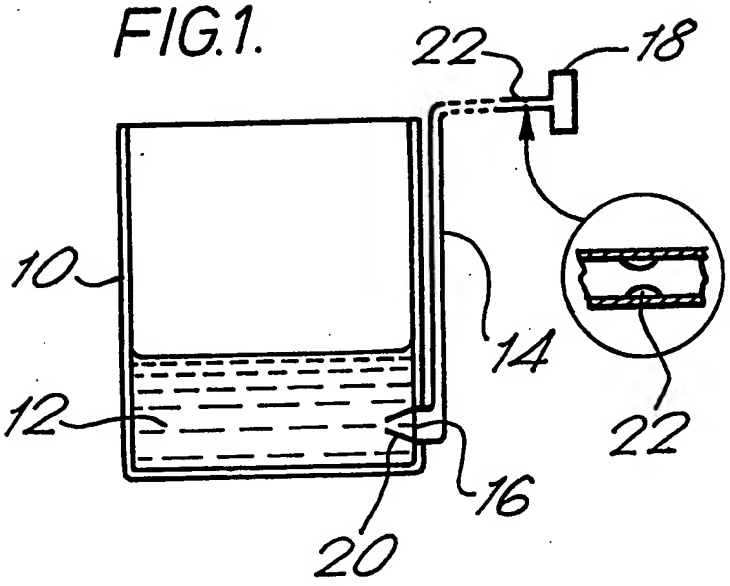
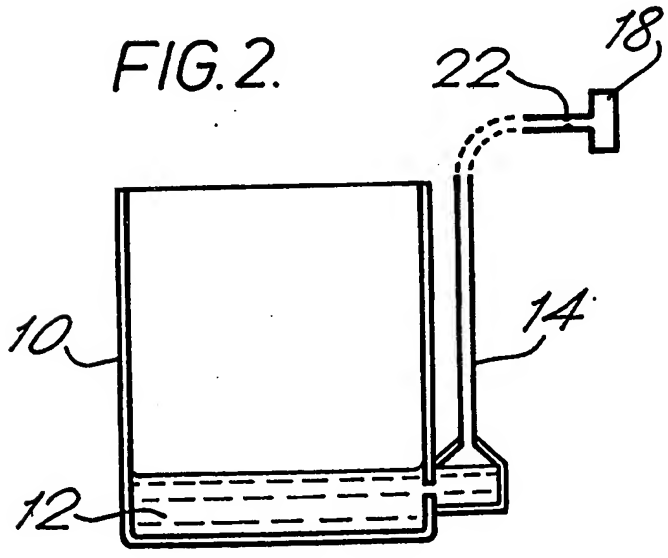


FIG.2.



SPECIFICATION

Apparatus for measuring liquid volume and/or flow rate

This invention relates to apparatus for the measurement of the volume of a liquid and/or the rate of flow of a liquid. The apparatus of the present invention has particular application to the measurement of the rate of flow of urine during micturition and the measurement of the volume of that flow at any time.

It is important in the clinical use of apparatus or equipment for urodynamic investigations to be able to measure liquid flow rates accurately over short periods of time for relatively small volumes of liquid. The response of the apparatus to any change must be rapid, but should not give rise to any appreciable oscillation of the output signal.

In accordance with the present invention there is provided apparatus for the measurement of the volume and/or rate of flow of a liquid, comprising a container into which the liquid is conducted so as to accumulate therein, means defining a gas chamber in communication with the interior of the container at or adjacent to its base, and a pressure transducer positioned to be responsive to changes in the pressure in said chamber resulting from the addition of liquid to the container.

The gas in the chamber is usually air.

Preferably, the gas chamber is in the form of a gas column with the transducer at the end of the column remote from the container.

A separating diaphragm may be provided between the liquid and the gas in the chamber, but this is not essential.

Preferably, the container is of substantially uniform cross-section. In a preferred embodiment of the invention some means of viscous damping to minimise oscillation is provided. Damping may be provided within the liquid alone and/or within the gas chamber between the container and the transducer. The output electrical signal from the transducer is also preferably filtered to improve the response.

The height of the liquid in the container is a measure of the volume of the liquid in the container at any time for a uniform cross-section container, and this, for a liquid of substantially constant density, gives rise to an increase in the pressure at the bottom of the container. This pressure increase, when communicated to the transducer via the gas chamber, gives an electrical output from the transducer which is approximately proportional to the volume of liquid. A measure of the flow rate can be obtained by electronic processing of this signal to derive the relevant values therefrom.

For the measurement of urine it is particularly important that the apparatus should be easy to clean. One advantage of the apparatus of the present invention is that the container can very easily be separated from the sensing transducer for cleaning purposes. Additionally, the sensing transducer itself does not come into contact with the liquid, being separated from it by the gas chamber.

In order that the invention may be more fully understood, two presently preferred embodiments of apparatus in accordance with the invention will now be described by way of example and with reference to the accompanying drawing, in which:

Figure 1 is a schematic side view of a first embodiment of apparatus; and,

Figure 2 is a similar schematic view of a second embodiment of apparatus.

Referring first to Fig. 1, this shows the lower portion of a container 10 of substantially uniform cross-section, here shown as a cylindrical container. Within the container is the liquid 12 which is being monitored. From adjacent to the bottom of the container 10 there extends upwards a tube 14 which is filled with a gas, usually air. A separating diaphragm 16 is let into the wall of the container 10 to separate the liquid in the container from the air within the tube 14. The upper end of the air-filled tube 14 is connected to a pressure transducer 18.

An important but not essential feature of the present invention is the provision of damping means within the liquid and/or within the air-filled column. Fig. 1 shows the provision of damping constrictions 20 within the liquid 12 adjacent to the diaphragm 16, and also the provision of damping constrictions 22 within the top of the tube 14 adjacent to the transducer 18. The damping constrictions 20 in the liquid may be in the form of a baffle around the diaphragm.

In the second embodiment, shown in Fig. 2, there is no separating diaphragm between the liquid and the column of air, and the tube defining the air column has a base portion which is an extension of the container so that the liquid flows laterally to fill or partially fill the bottom of the tube 14. The damping constriction 20 within the liquid is here produced by narrowing the inlet to the side extension of the container.

The volume of air within the tube 14 is kept relatively small, for example of the order of 5 ml when a maximum volume of 1 litre of liquid is to be measured. Preferably, the height of the liquid only rises by about 200 mm within the container so that the pressure developed is small and only compresses the air by a small amount, typically 2% maximum or about 0.1 ml.

Because surface tension effects can give rise to very large errors in measuring the pressure due to the rise in liquid height, it is important to minimise these effects. Consequently, a relatively large area of interface between the liquid 12 and the air in the

container above it is provided for, while keeping the volume of air in the tube 14 relatively small.

The electrical output from the transducer 18 is amplified and the flow rate can be derived from this signal by the use of an analog or digital filter system. In a preferred embodiment of the invention, the analog signal representing volume is converted to digital form and this converted signal is normalised by means of a microcomputer and is processed to generate the flow values. In this way the flow rate at any time during micturition, and the maximum flow rate, can easily be derived, together with the correspoinding urine volume figures, etc. The complete flow and volume versus time curves, together with the relevant numerical values, can be displayed on a visual display unit or printed out to give hard copy for inclusion in patient notes, etc. after the investigation.

The use of damping within the liquid and air, coupled with the filtering of the resultant electrical signal, means that a stable response to a "step" change in the flow rate can be obtained in less than 1 second.

One advantage of the use of a computer to carry out the signal processing is that the start of micturition can be made to initiate the recording process, and yet that recording can still cover the period just preceding the start. This is particularly important because it enables the user to set up the instrument and let the patient micturate at any suitable time without the patient having to perform any other action prior to micturition in order to initiate the recording. This means that the initial flow, which may be of clinical significance, is recorded in full from a few seconds prior to the flow which triggers the start of recording.

The calibration of the apparatus can be carried out by adding known volumes or weights of liquid to the container and generating a calibration curve within the computer. This need not necessarily assume a linear relationship between volume changes and the resultant electrical output signal from the transducer 18.

Although the apparatus of the present invention has particular application to urodynamic investigations, it is not limited to that particular use and has general application to the measurement of the volume of liquids and/or the rate of flow of such liquids.

CLAIMS

1. Apparatus for the measurement of the volume and/or rate of flow of a liquid, comprising a container into which the liquid is conducted so as to accumulate therein, means defining a gas chamber in communication with the interior of the container at or adjacent to its base, and a pressure transducer positioned to be responsive to changes in the pressure in said chamber resulting from the addition of liquid to the container.

2. Apparatus according to claim 1, wherein the gas chamber is in the form of a gas column with the transducer at the end of the column remote from the container.

3. Apparatus according to claim 1 or 2, wherein a diaphragm is provided to separate liquid in the container from the gas in the chamber.

4. Apparatus according to any preceding claim, which includes damping means within the gas chamber.

5. Apparatus according to claim 4 when dependent on claim 2, in which the gas chamber damping means comprises one or more constrictions in the column.

6. Apparatus according to claim 5, which includes a constriction adjacent to the transducer.

7. Apparatus according to any preceding claim, which includes damping means within the container to damp oscillations in liquid within the container.

8. Apparatus according to claim 7, in which the container damping means comprises one or more baffles adjacent to where the gas chamber is in communication with the container.

9. Apparatus according to claim 1 or 2, in which the means defining the gas chamber comprises an extension to the container at or adjacent to the base thereof, said extension being arranged to fill with liquid from the container, thereby to compress the gas in the gas chamber.

10. Apparatus according to claim 9, in which there is a restricted flow of liquid from the container into the extension.

11. Apparatus according to any preceding claim, in which the capacity of the container and the volume of the gas chamber are such that the gas in the chamber can be compressed by about 2% at the maximum.

12. Apparatus according to any preceding claim, in which the pressure transducer produces an analog output signal which is filtered and converted to digital form before being processed by computer means.

13. Apparatus according to any preceding claim, adapted for urodynamic analysis.

14. Apparatus for the measurement of the volume and/or rate of flow of a liquid substantially as hereinbefore described with reference to the accompanying drawings.

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